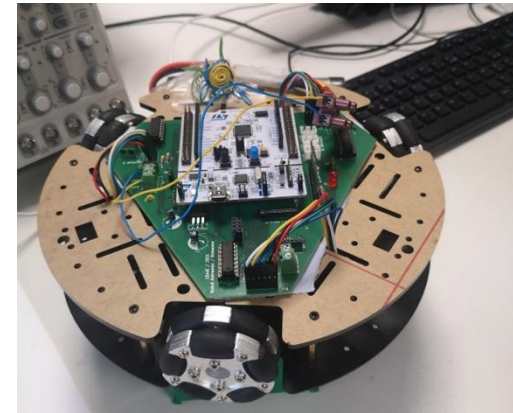
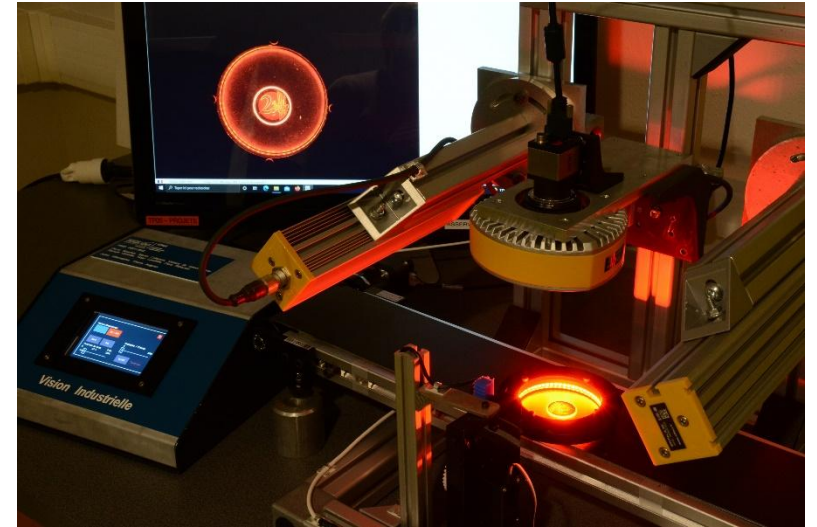
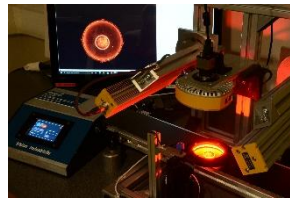


Vision Industrielle

TD Opto-Electronique

Julien VILLEMEJANE



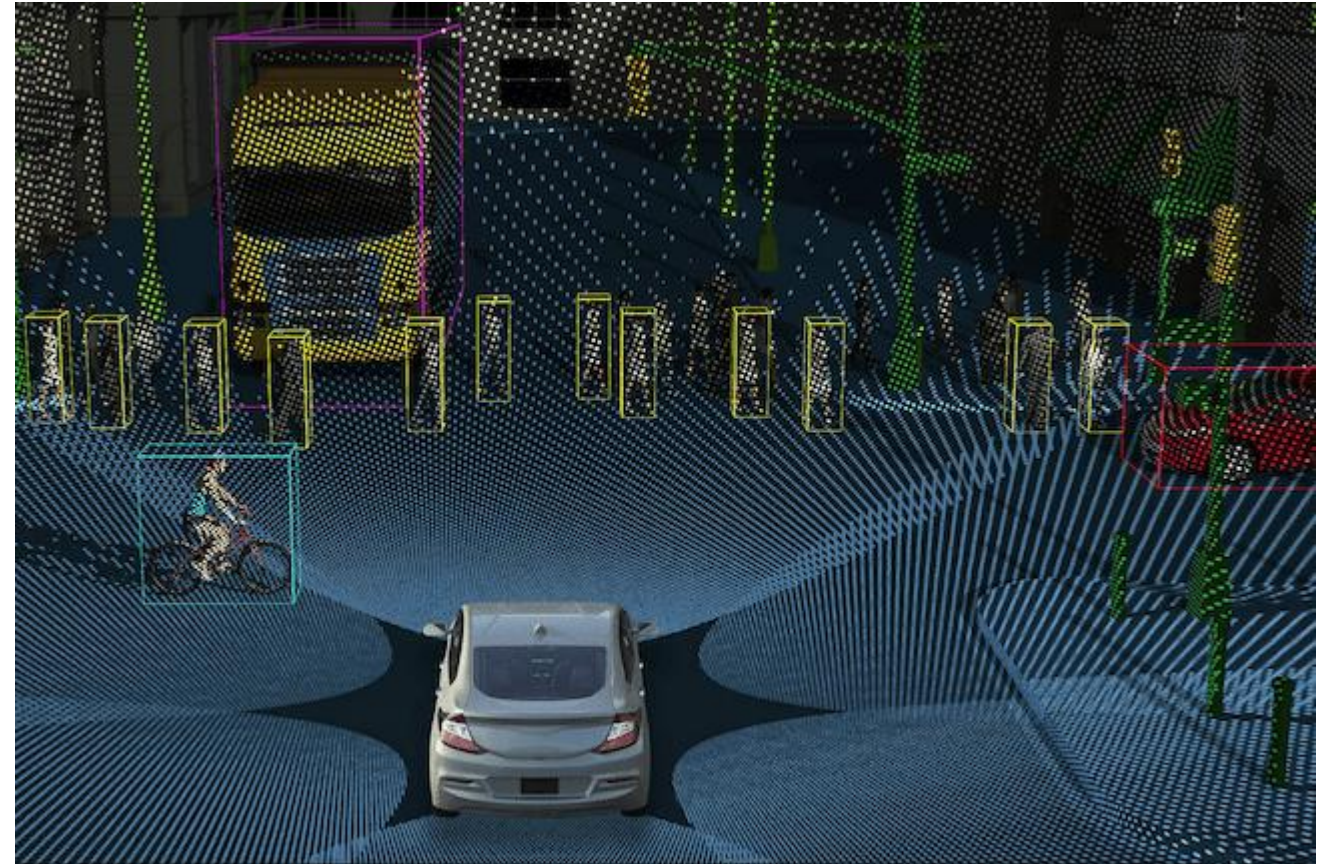


Vision Industrielle

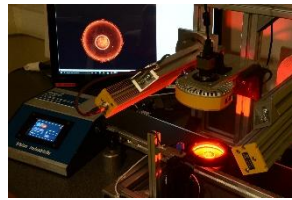
Machine Vision



https://www.keyence.fr/landing/lpc/vision-industrielle_fr_sem_190417.jsp



<https://www.frenchweb.fr/aeye-16-millions-de-dollars-pour-ameliorer-les-capteurs-lidar-des-voitures-autonomes/296495>



Vision Industrielle

Machine Vision

Système basé sur un **système imageant** permettant d'**automatiser les procédés d'inspection** de produits



Prendre une décision

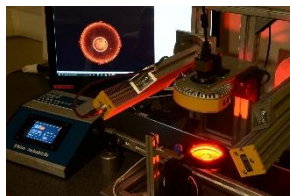
Contrôle Qualité / Tri d'objets

- Détecter des défauts ou irrégularités
- Vérifier l'uniformité de surface
- Compter ou/et trier des objets

Gain en efficacité et en répétabilité

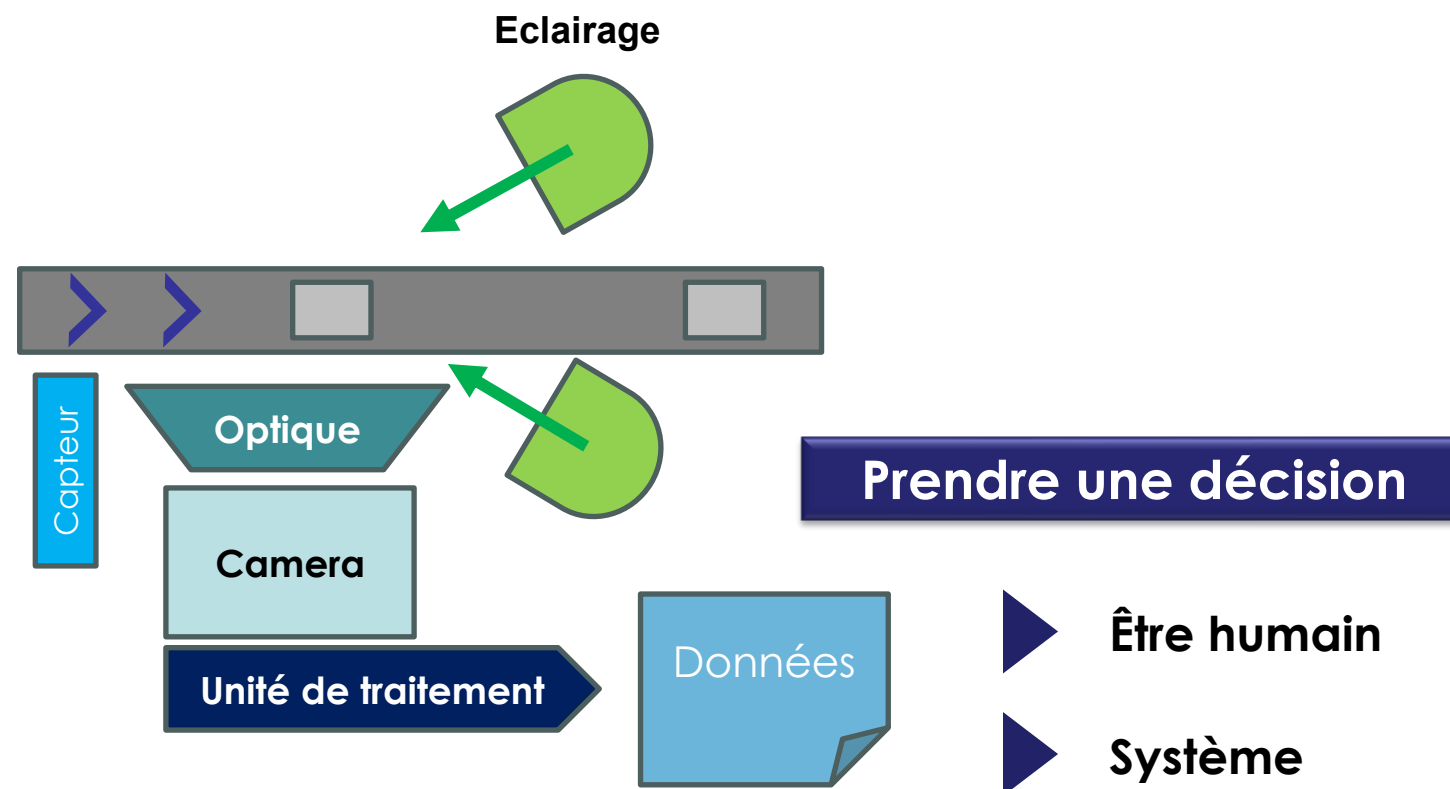
- Inspection en temps réel et à vitesse élevée
- Opérations en continu

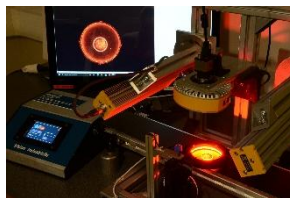




Vision Industrielle

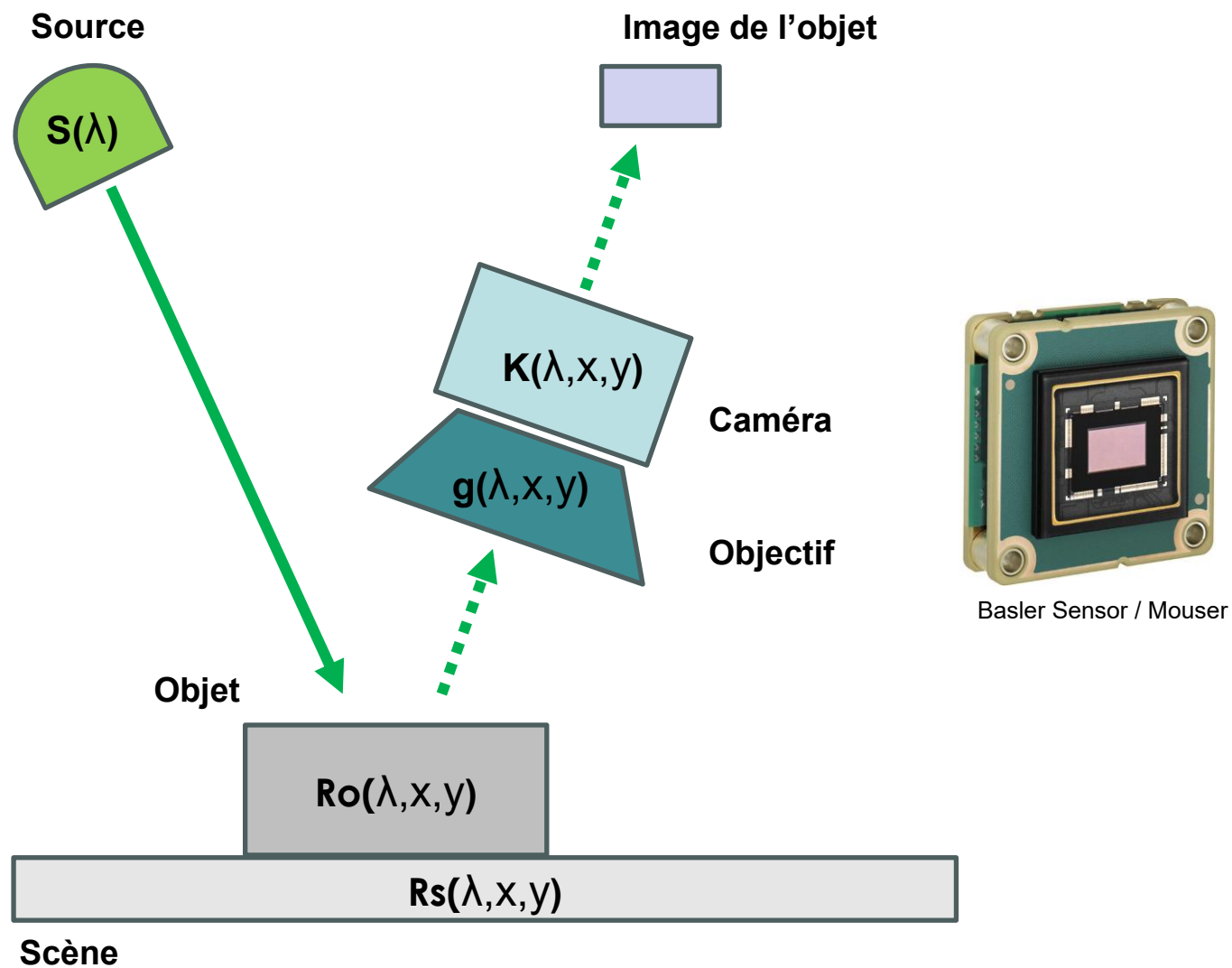
Éléments constitutifs





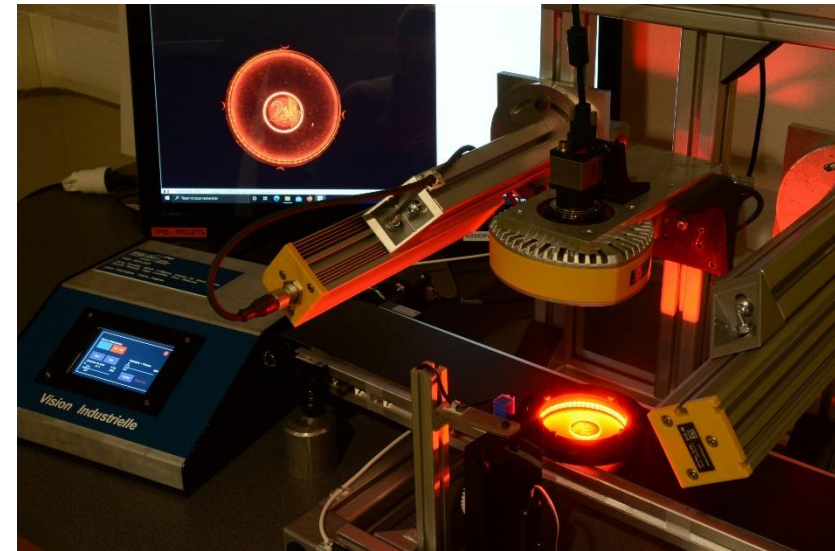
Vision Industrielle

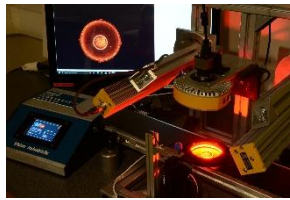
Modélisation de la chaîne



Objets / Sources

Eclairage / Colorimétrie

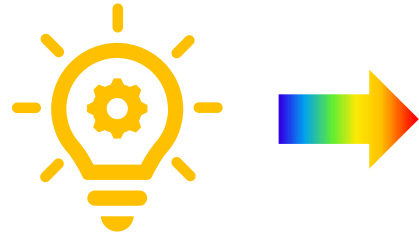




Sources

Sources primaires

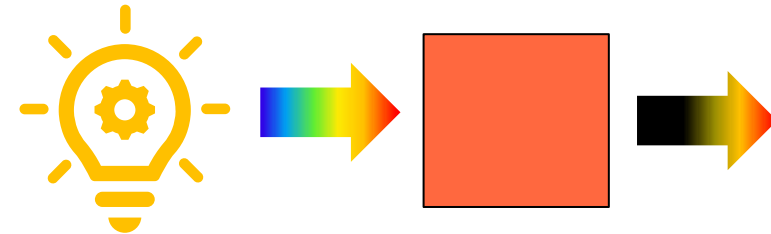
Produisent leur propre lumière



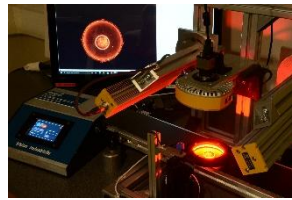
Caractérisées par leur **spectre d'émission**

Sources secondaires

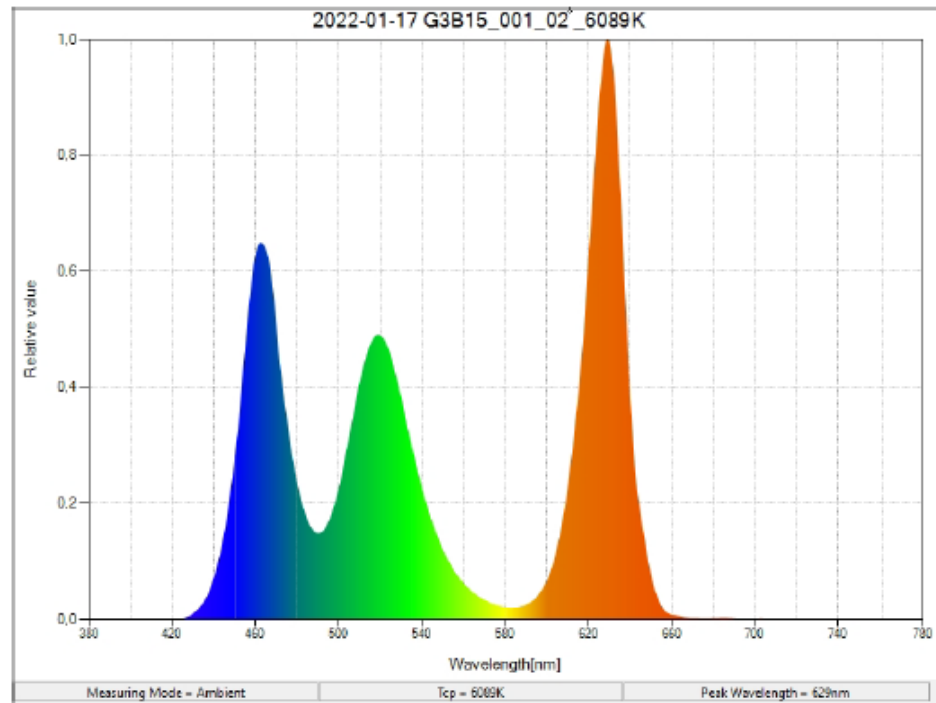
Diffusent la lumière produite par une source primaire



Caractérisées par le **spectre de l'illuminant**
et leur **spectre en réflectance**



Spectre d'émission

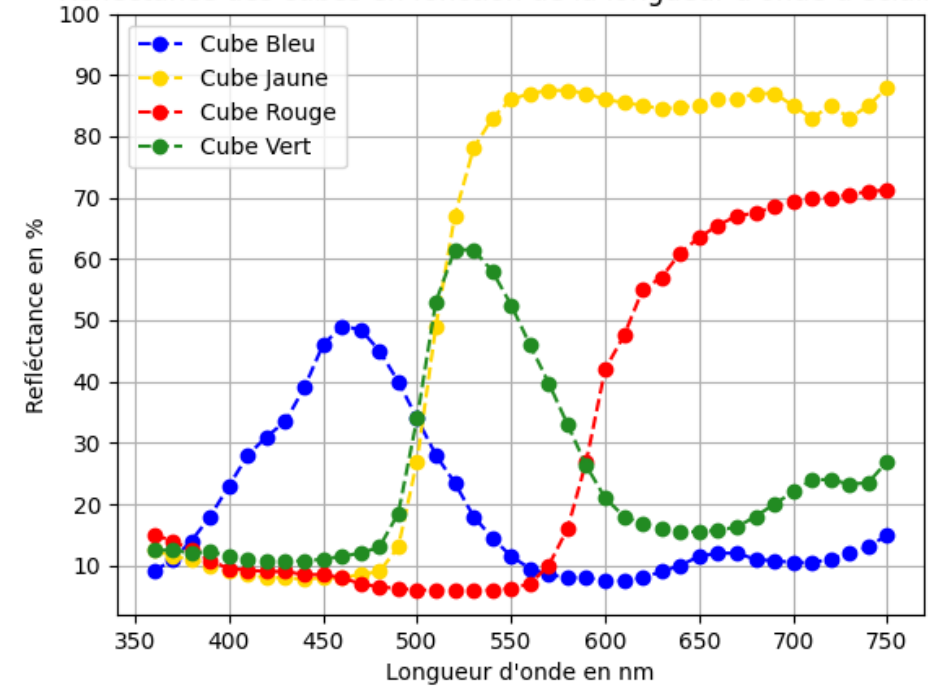


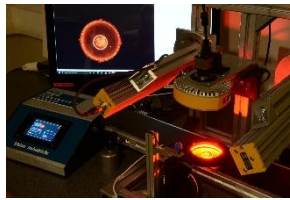
Sources

Réflectance



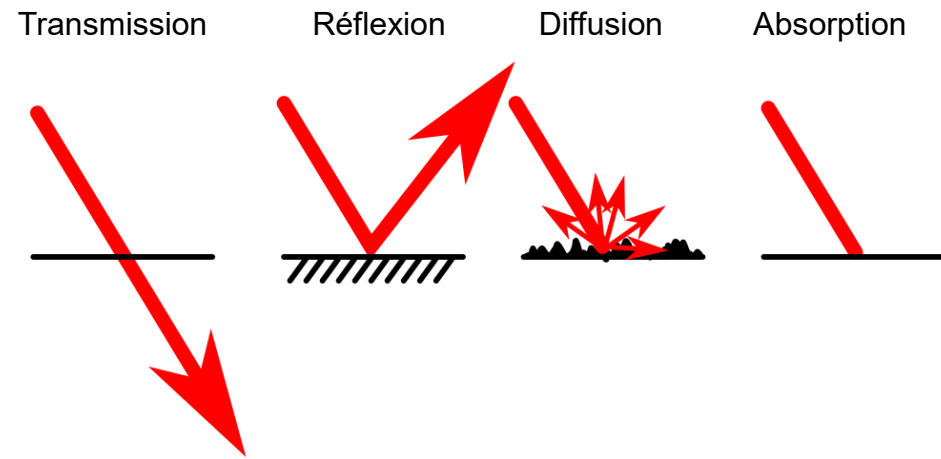
Réflectance des cubes en fonction de la longueur d'onde d'éclairage





Eclairage

Impact du type d'éclairage / Nature des objets



Directif



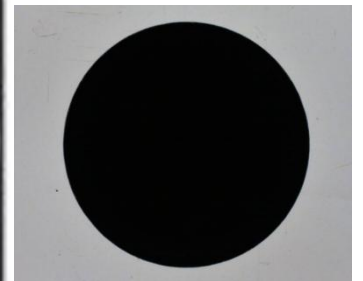
Diffus



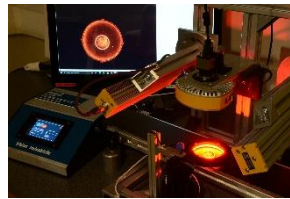
Rasant



Coaxial

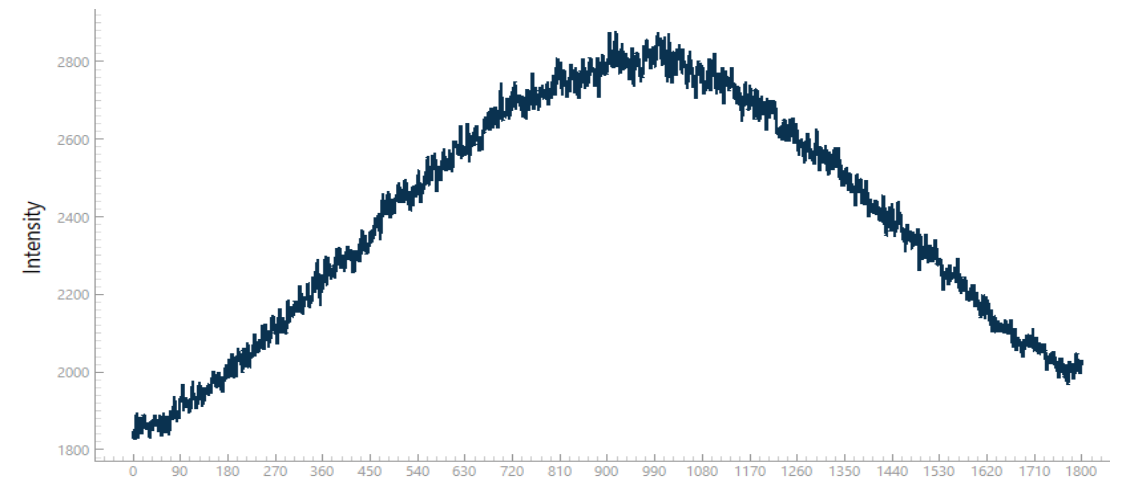
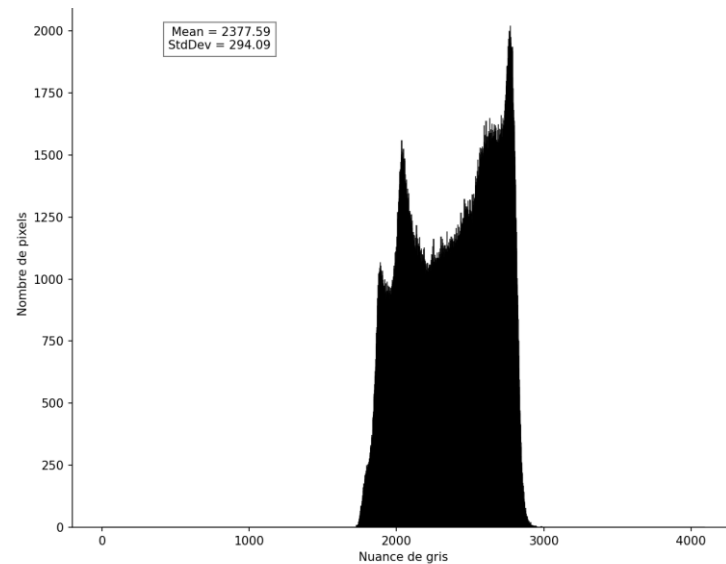
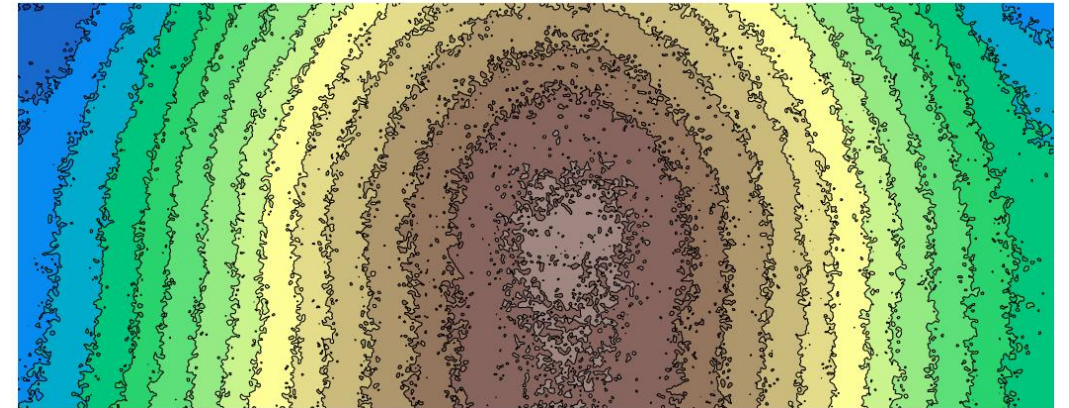


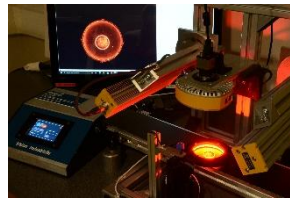
Retro



Eclairage

Uniformité de l'éclairage





Colorimétrie

*Image prise par un capteur optique
(sans balance des blancs)*



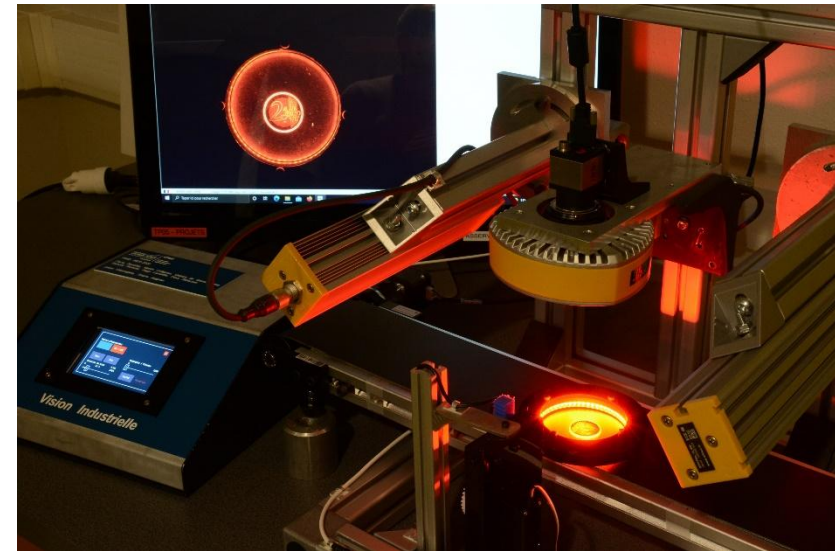
*Image vue par un humain
(grâce à l'adaptation chromatique)*

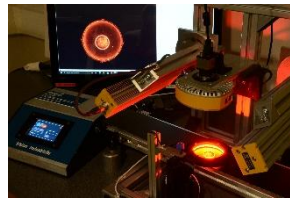


► Fairchild, Color Appearance models

Objectif optique

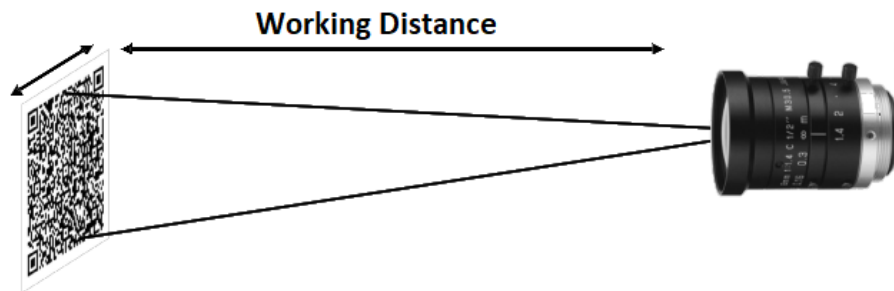
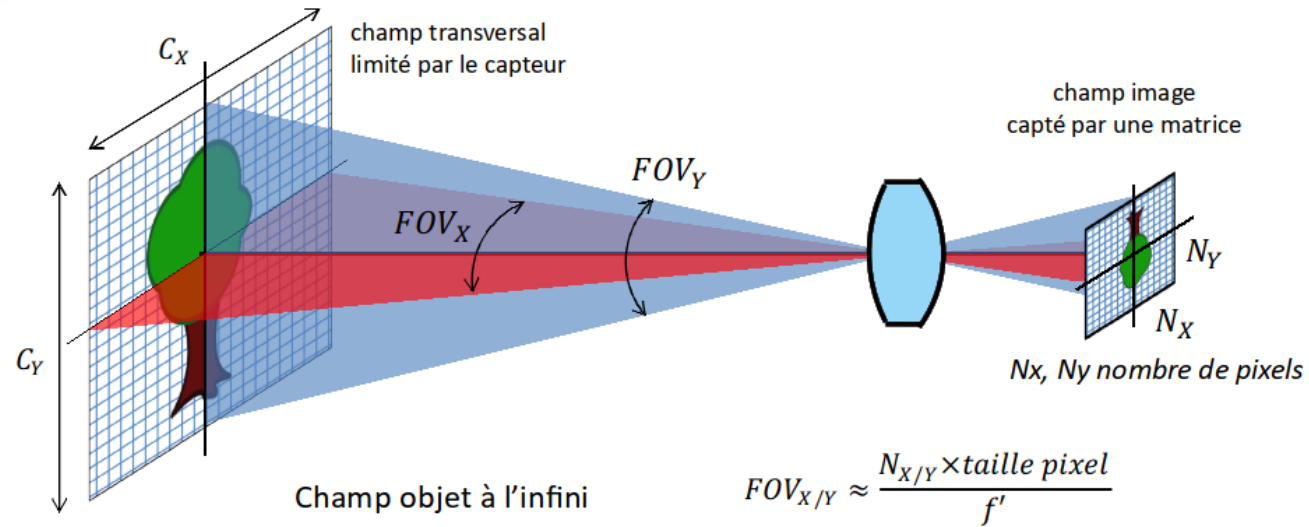
Créer une image exploitable

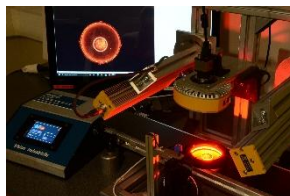




Objectif optique

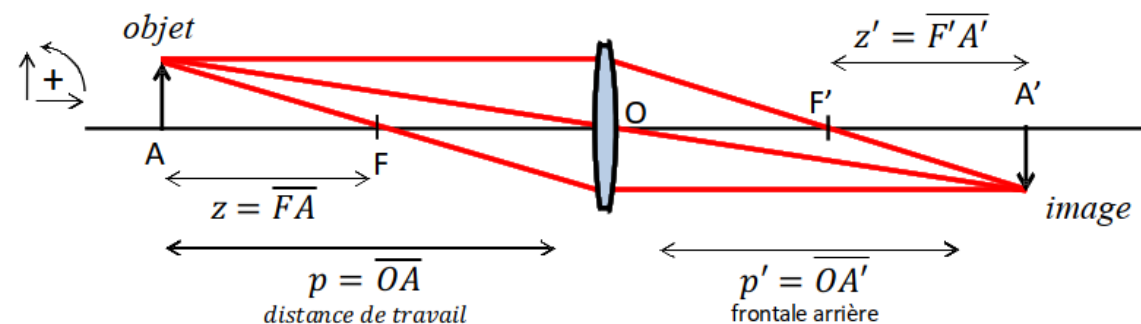
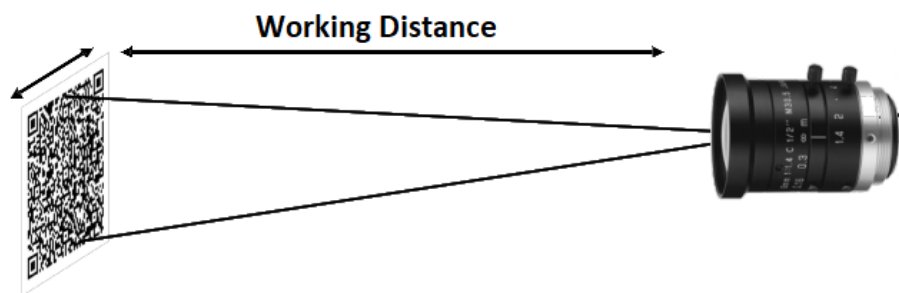
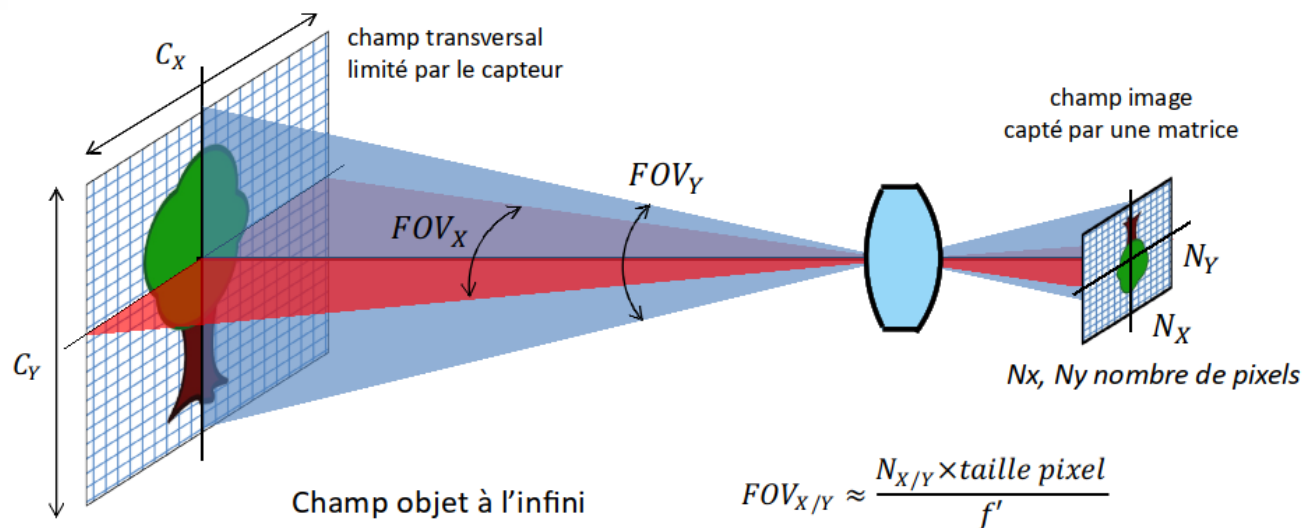
Créer une image





Objectif optique

Créer une image



taille image
grandissement transversal

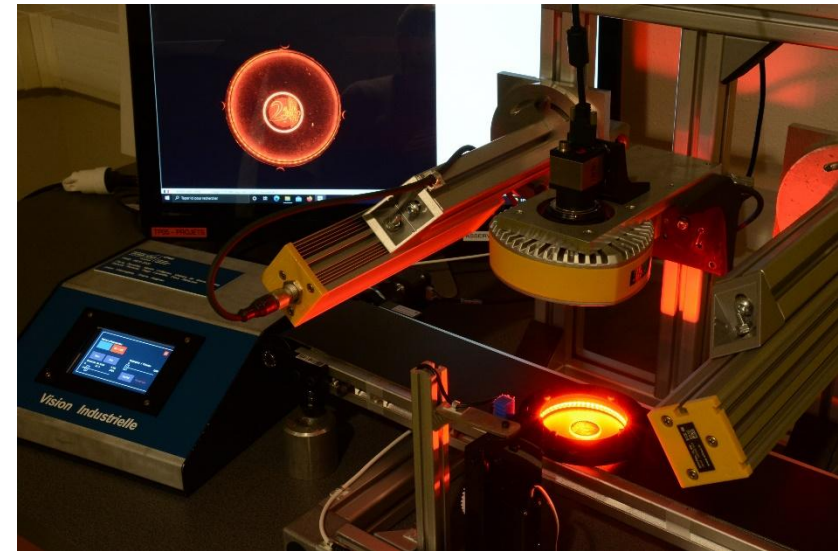
$$g_y = \frac{y'}{y} = \frac{p'}{p} = -\frac{z'}{f'} = -\frac{f}{z}$$

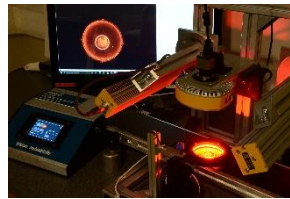
grandissement longitudinal

$$g_z = \frac{\delta p'}{\delta p} = (g_y)^2$$

Caméra numérique

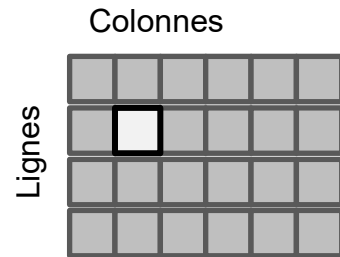
Echantillonnage / Quantification
Colorimétrie



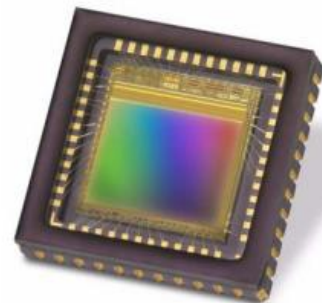


Caméra numérique

Matrice de pixel



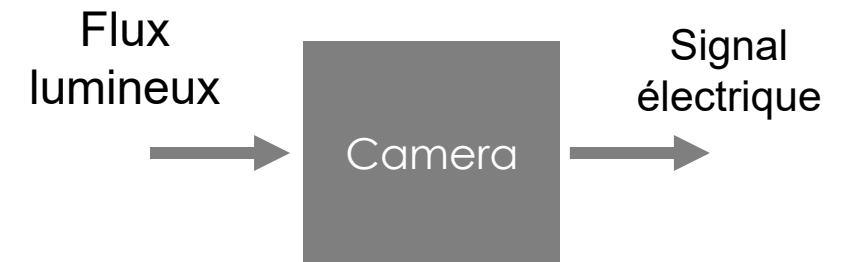
IDS UI-1240SE-C-HQ



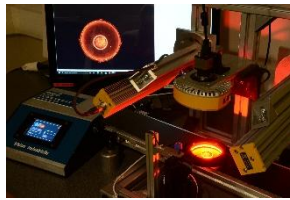
e2v sensor EV76C560ACT

Camera

Système qui transforme un **flux lumineux** en un **signal électrique mesurable**

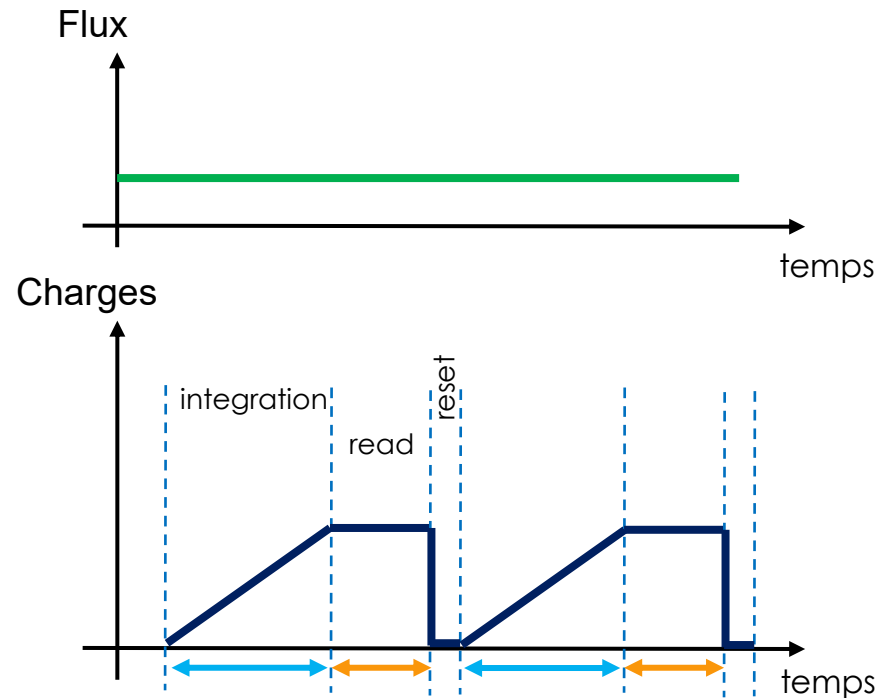
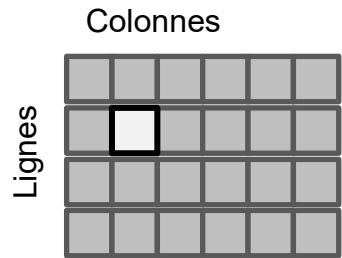


Taille d'un pixel de l'ordre de 2 à 10 μm



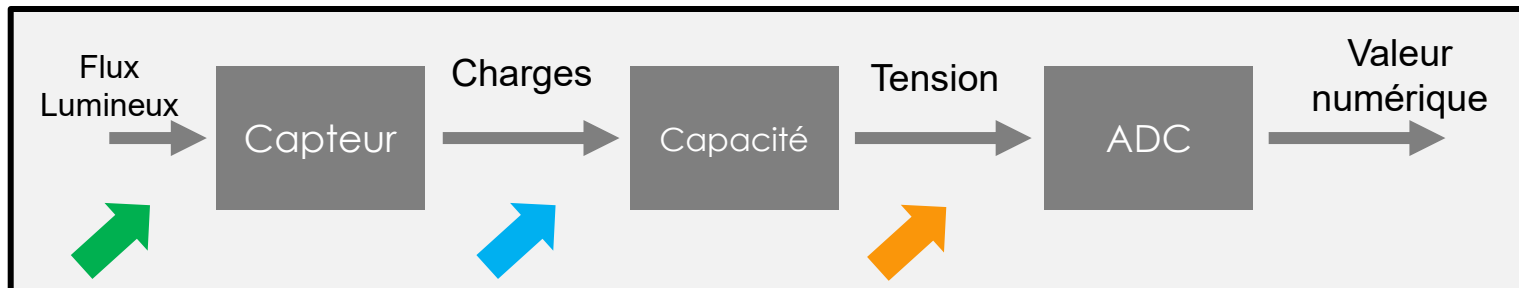
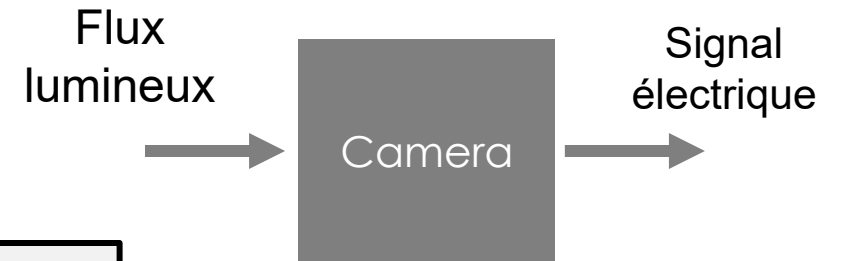
Caméra numérique

Matrice de pixel



Camera

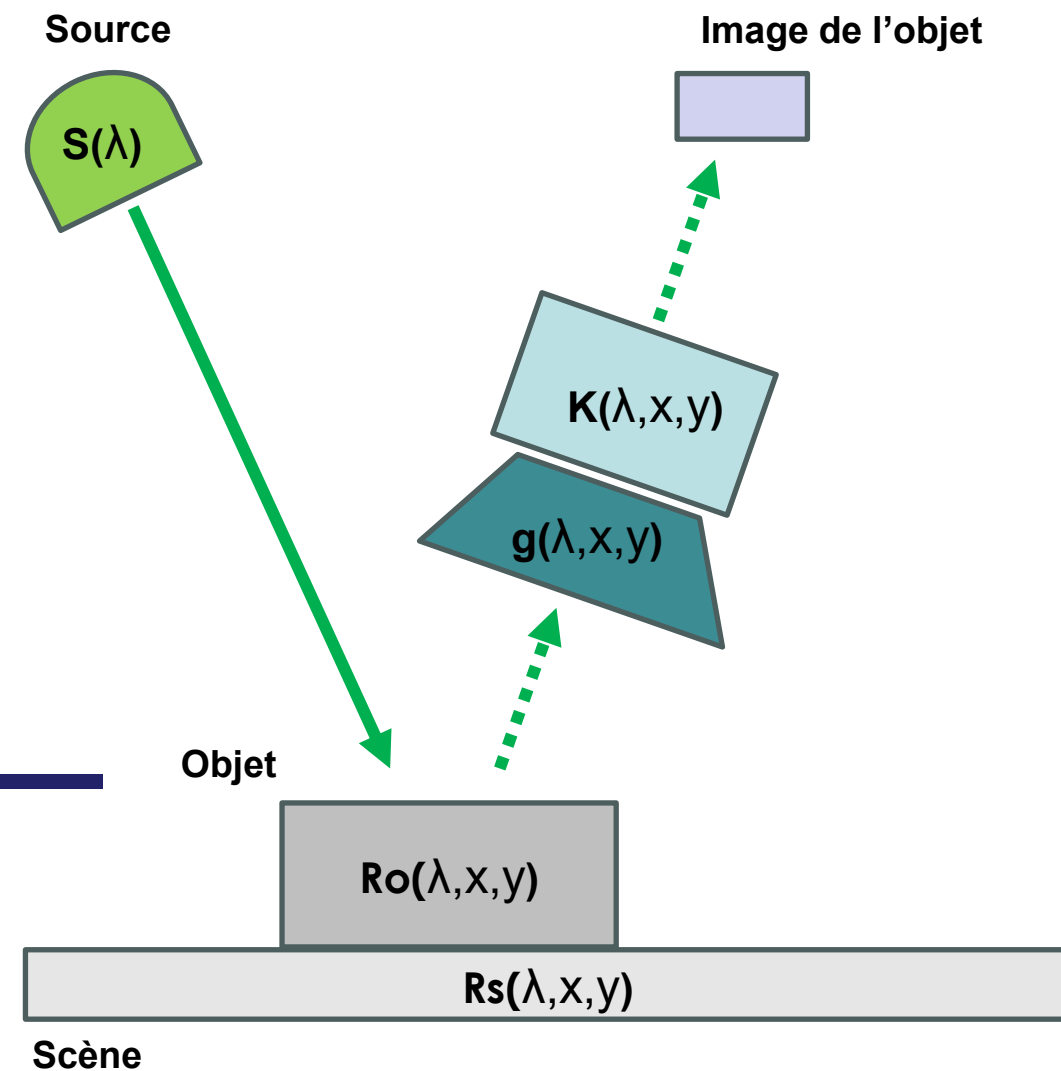
Système qui transforme un **flux lumineux** en un **signal électrique mesurable**

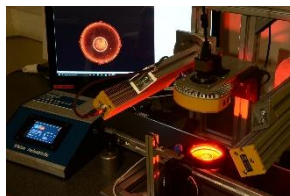


Taille d'un pixel de l'ordre de 2 à 10 μm

Méthodes

Caractérisation / Mesure

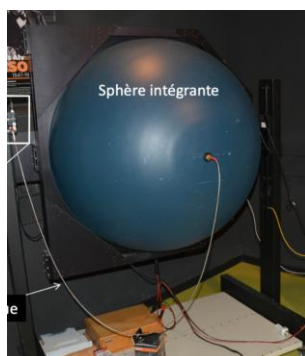
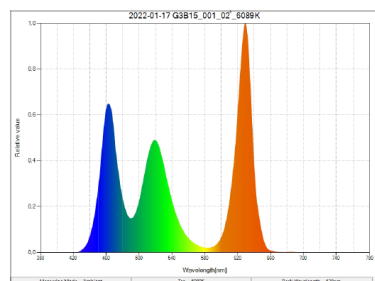




Sources / Objets

Caractérisation / Mesure

Spectre d'émission



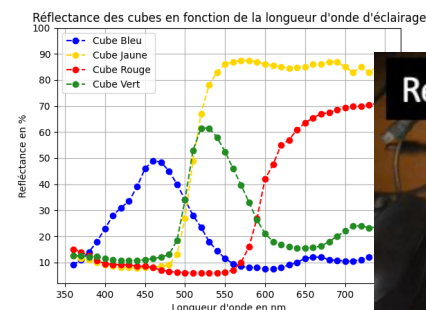
Intensité
Spectre
Réflectance

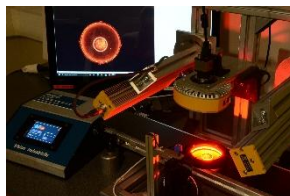
Directivité
Uniformité
Etat de surface

Système de photodetection (photodiode par exemple) ou Luxmètre
Spectromètre / Spectro colorimètre
Réflectancemètre (source secondaire)

Système de photodetection monte sur un système permettant de contrôler l'angle
Image d'un plan éclairé par la source (camera par exemple et objectif)
Rugosimètre ou Profilomètre optique

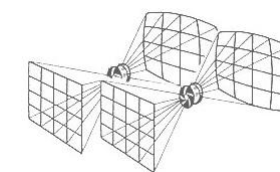
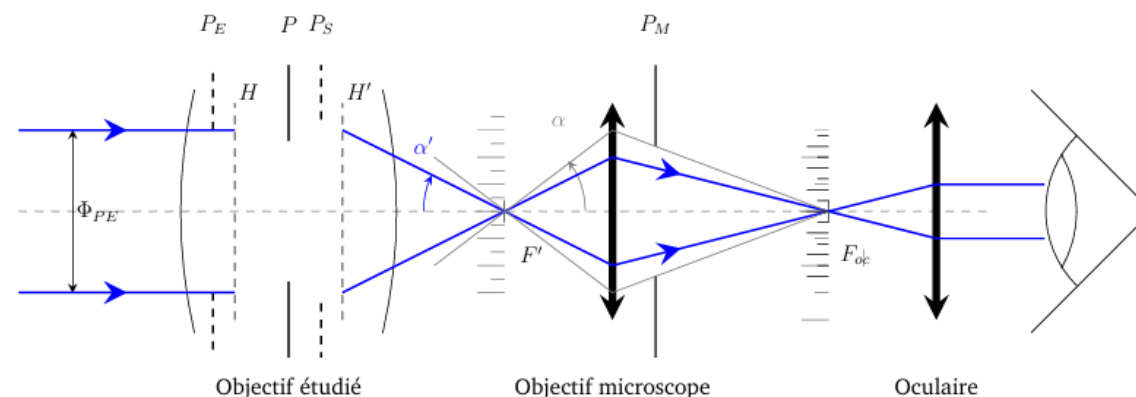
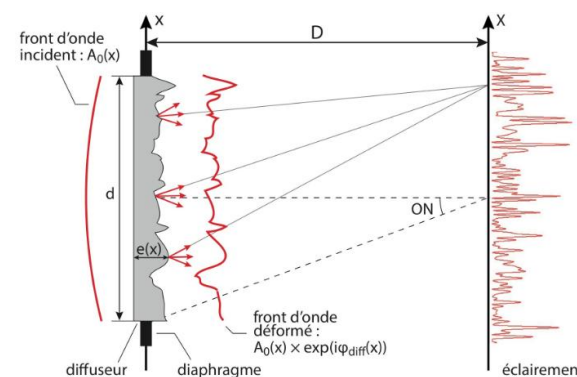
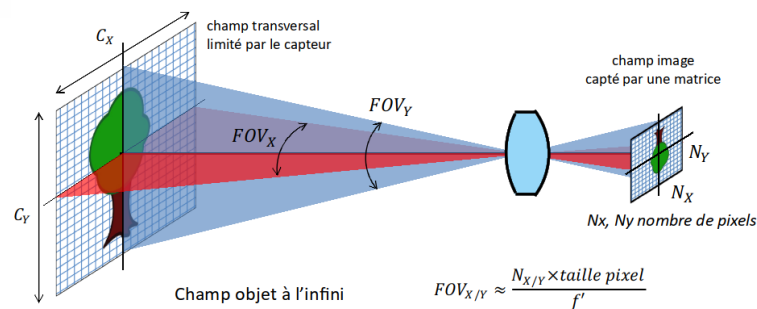
Réflectance





Objectifs

Caractérisation / Mesure



Focale / Champ de vision
Spectre

Résolution optique / Distorsions

Aberrations / Front d'onde

Banc optique de mesure (collimateur et rails de déplacement) - voir TP S5/S6.

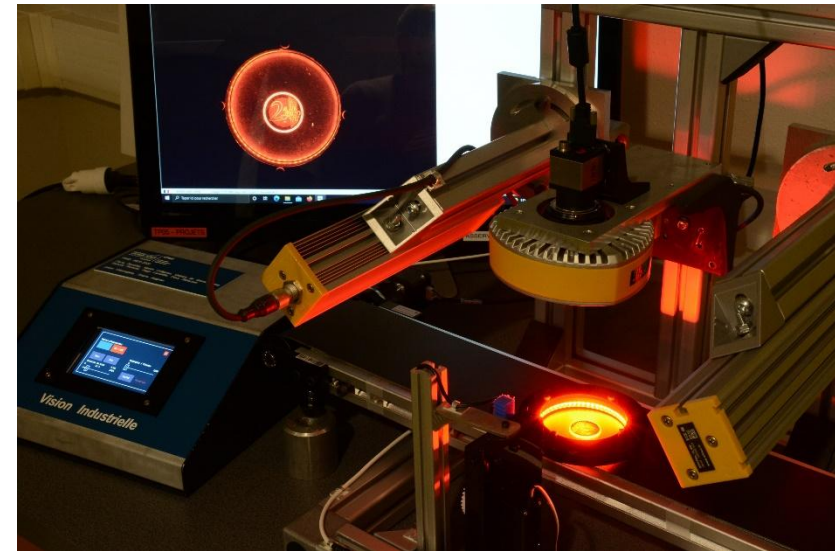
Spectrocolorimètre

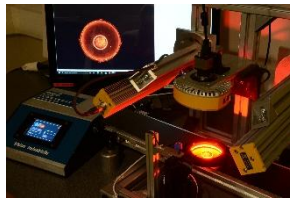
Mires et système d'image.

Interféromètre (Fizeau par exemple).

Traitement d'image

Pré-traitement / Segmentation / Classification





Traitement d'images

Objectif



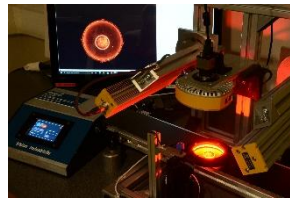
Image brute 'RAW' / Caméra

- **Bruitée**
- Mauvais contraste
- Eclairage non uniforme
- ...



Image souhaitée / Contours bien définis

- Zones homogènes
- Transitions nettes



Traitement d'images

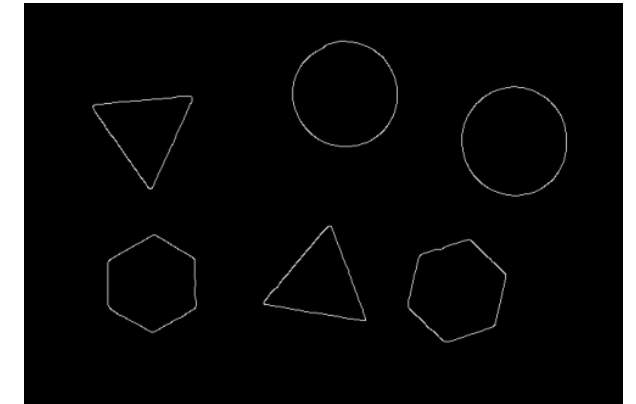
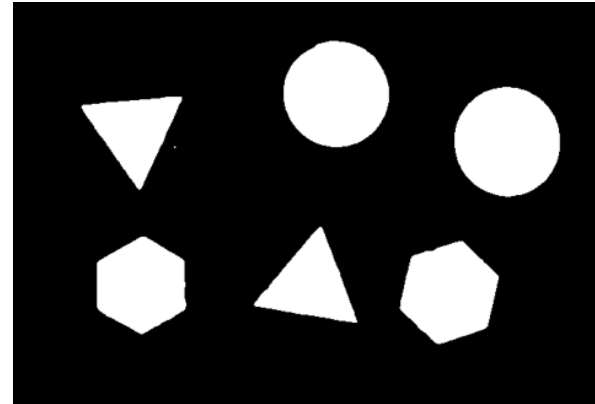
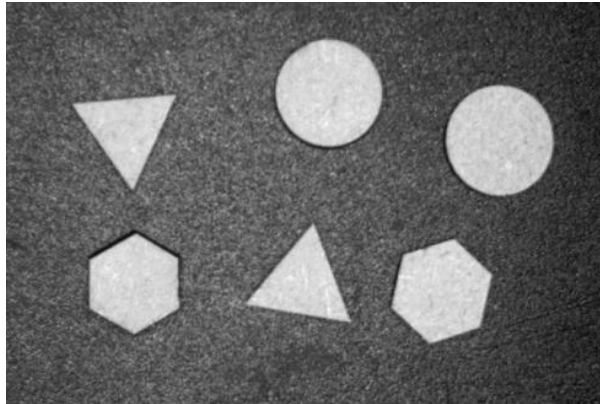


Image brute 'RAW' / Caméra

- **Bruitée**
- Mauvais contraste
- Eclairage non uniforme
- ...

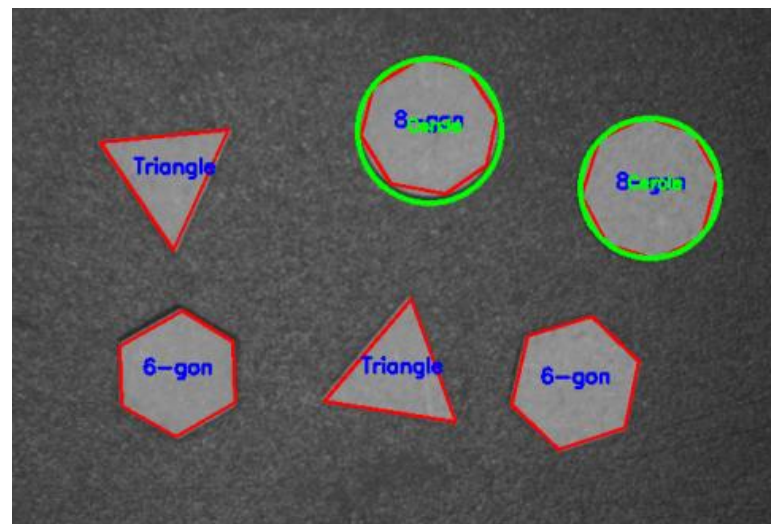
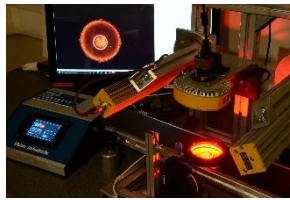


Image souhaitée / Contours bien définis

- Zones homogènes
- Transitions nettes



Traitement d'images

Images numériques

Image continue

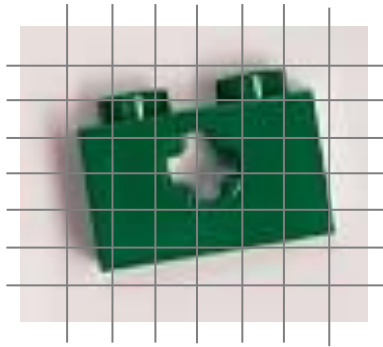
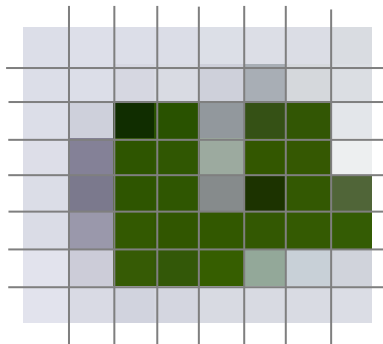


Image numérique : projection sur une matrice d'une image continue



8 x 8 grid



16 x 16 grid

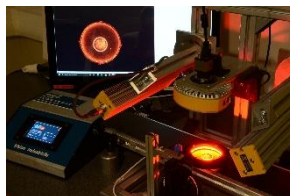


32 x 32 grid

Image numérique

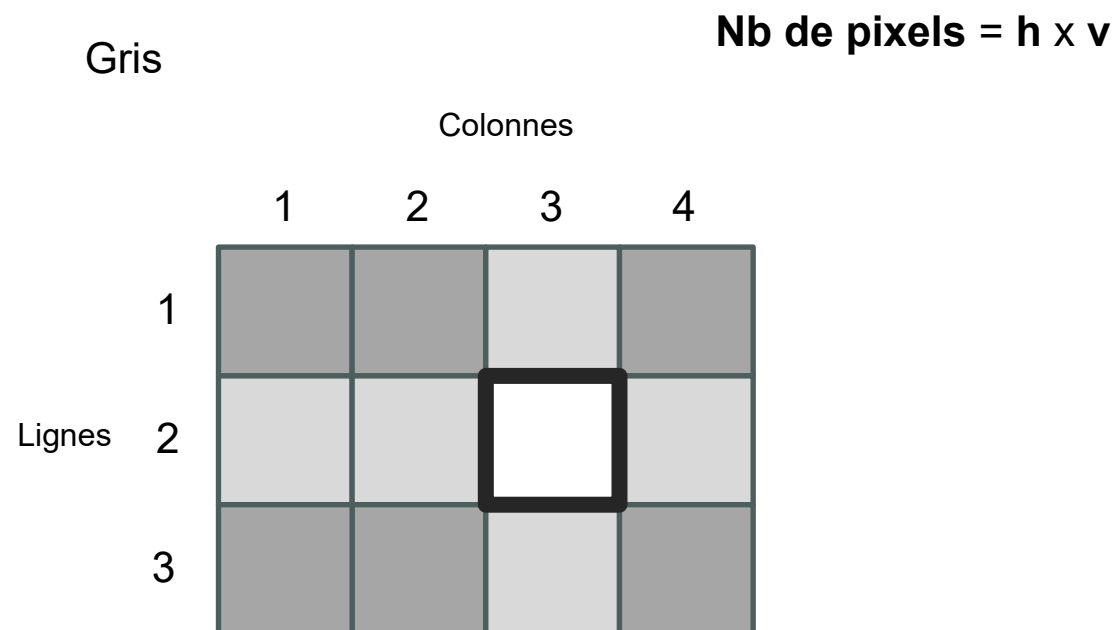
Représentation d'une **image**
sous forme numérique

*Pour être **sauvegardée**, **traitée**
et **affichée** par des ordinateurs
ou des systems numériques.*

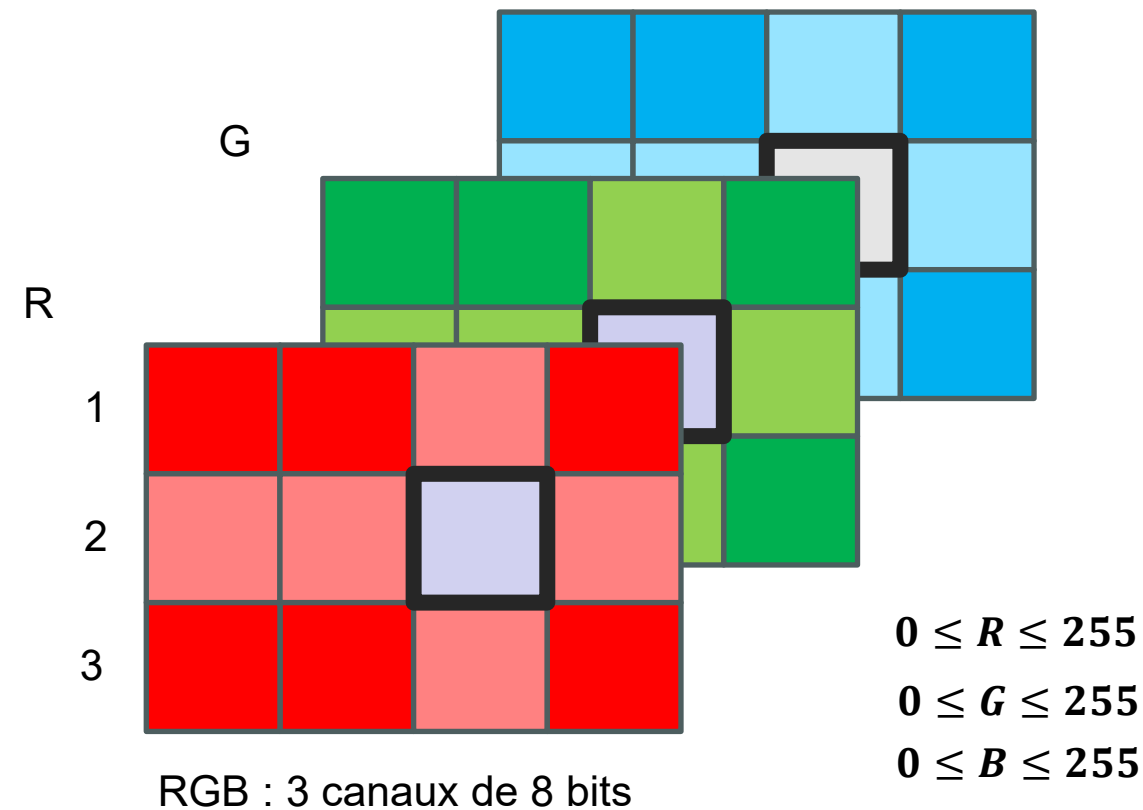


Traitement d'images

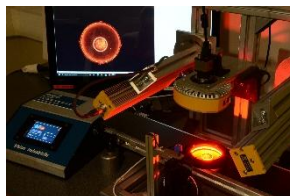
Images numériques / Gris ou RGB



Chaque pixel est converti sur **n bits**.



R=200, G=100, B=50



Traitement d'images

kernel

-1	0	-2
1	5	1
-2	0	-1

original image

5	8	4	2	3	1	5
9	5	1	8	7	6	2
5	7	1	5	6	8	7
5	8	2	8	4	3	3
5	6	6	7	2	5	1

Filtrage / Convolution

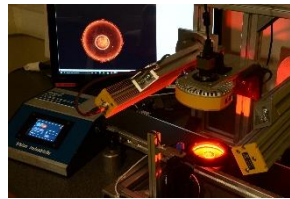
5	8	4	2	3	1	5
9	5	1	8 x -1	7 x 0	6 x -2	2
5	7	1	5 x 1	6 x 5	8 x 1	7
5	8	2	8 x -2	4 x 0	3 x -1	3
5	6	6	7	2	5	1

filtered image

$$R = -8 + 0 - 12 + 5 + 30 + 8 - 16 + 0 - 3$$

$$R = 4$$

				4		

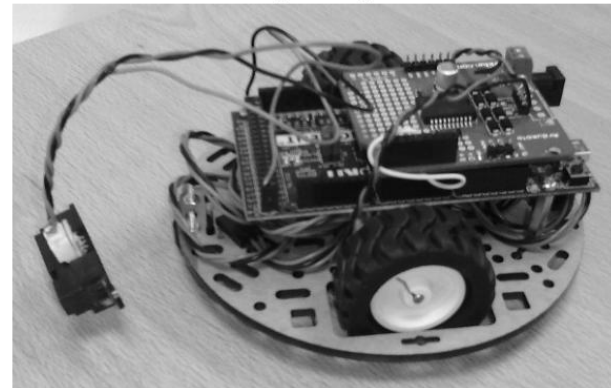


Traitement d'images

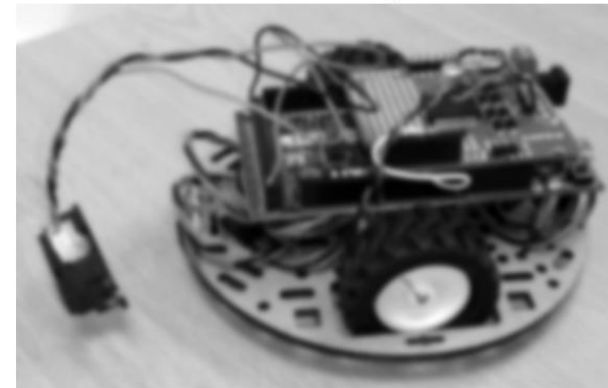
Filtrage / Convolution

Suppression de détails insignifiants

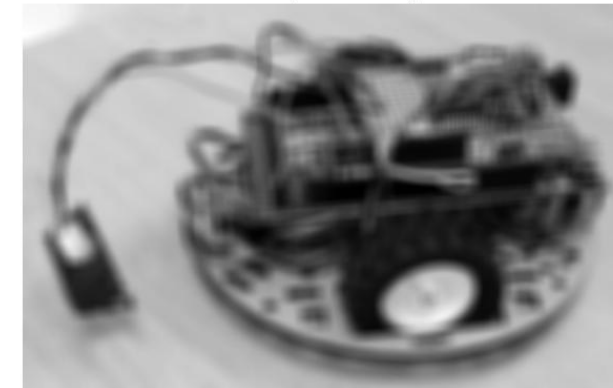
Original Image



Gaussian Blur Image



Median/Box Blur Image



1	4	7	4	1
4	16	26	16	4
7	26	41	26	7
4	16	26	16	4
1	4	7	4	1

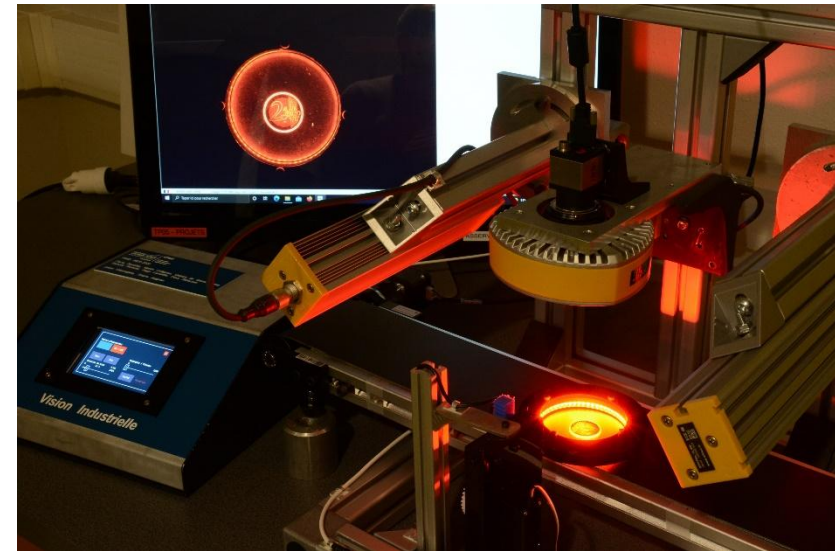
Gaussian Kernel
($\times 1/273$)

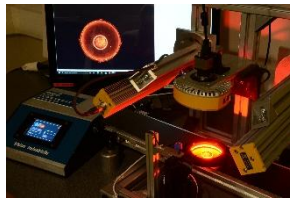
Mean Kernel ($\times 1/(N \times M)$)

1/9	1/9	1/9
1/9	1/9	1/9
1/9	1/9	1/9

Convolution 1D

Exercices





Convolution 1D

Exercices

$$A3 = \begin{bmatrix} 1 & 1 & 1 \end{bmatrix}$$

$$A5 = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 \end{bmatrix}$$

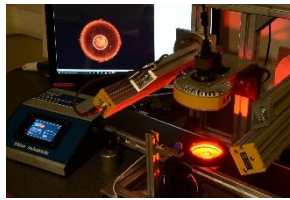
$$B = \begin{bmatrix} 1 & 4 & 1 \end{bmatrix}$$

$$C1 = \begin{bmatrix} -1 & 0 & 1 \end{bmatrix}$$

$$C2 = \begin{bmatrix} 1 & 0 & -1 \end{bmatrix}$$

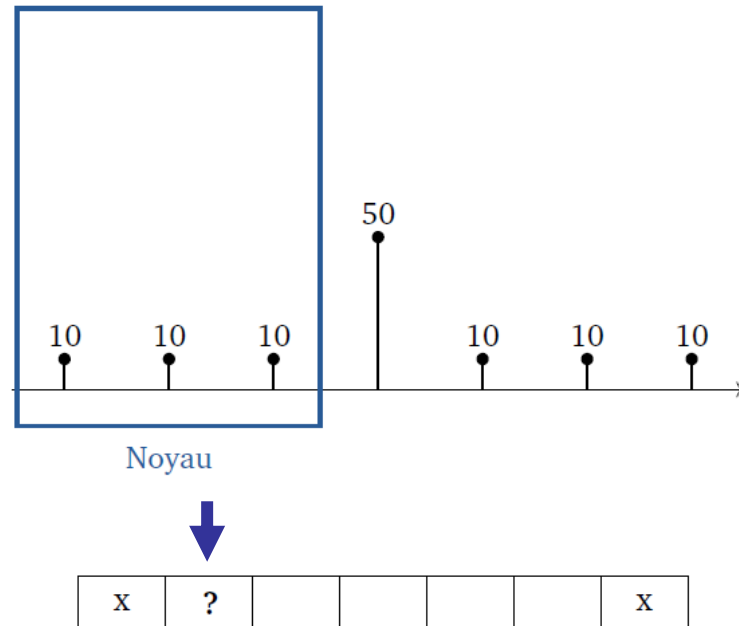
$$S1 = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 100 & 100 & 100 & 100 & 100 \end{bmatrix}$$

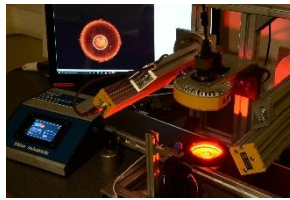
$$A3 > \begin{bmatrix} & & & & & & & & & \end{bmatrix}$$



Convolution 1D

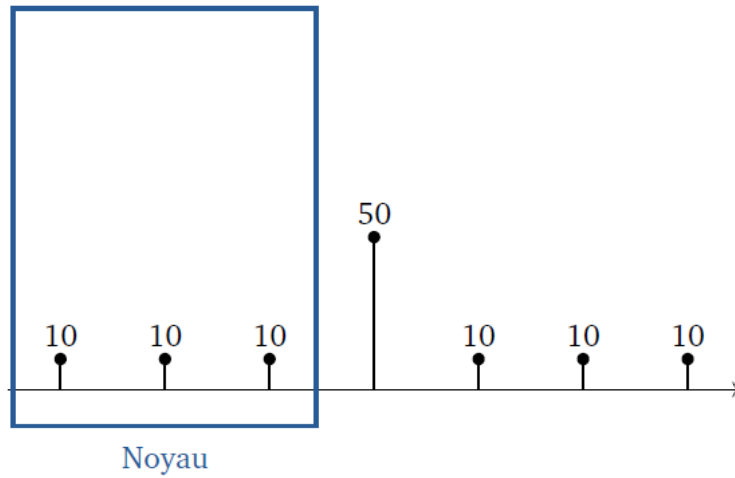
Principe





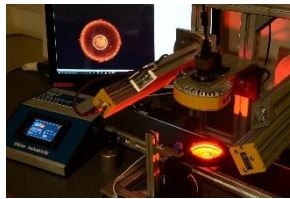
Convolution 1D

Principe



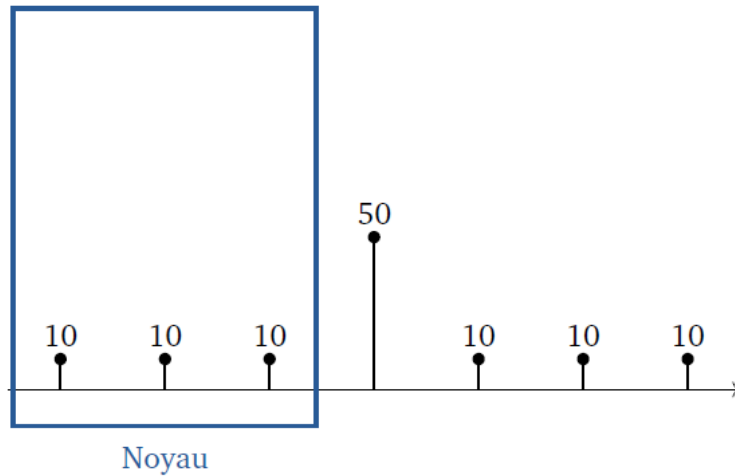
x	?					x
---	---	--	--	--	--	---

x	30					x
---	----	--	--	--	--	---



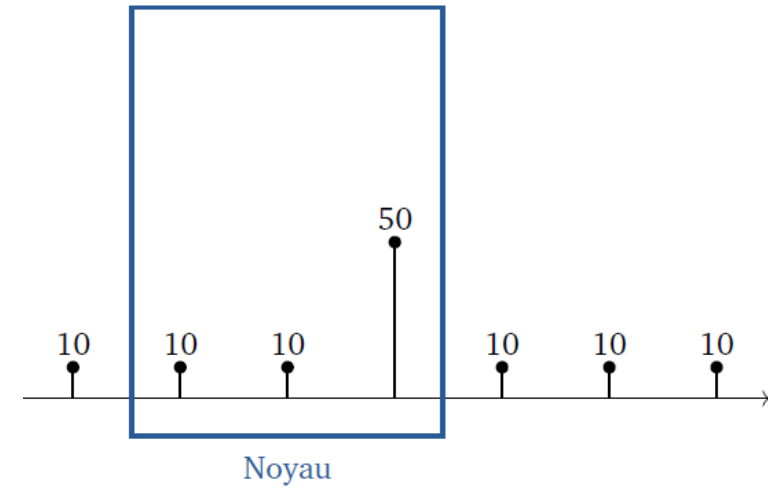
Convolution 1D

Principe

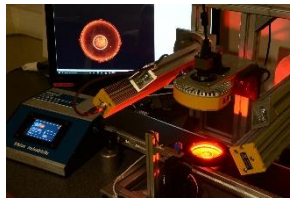


x	?					x
---	---	--	--	--	--	---

x	30					x
---	----	--	--	--	--	---

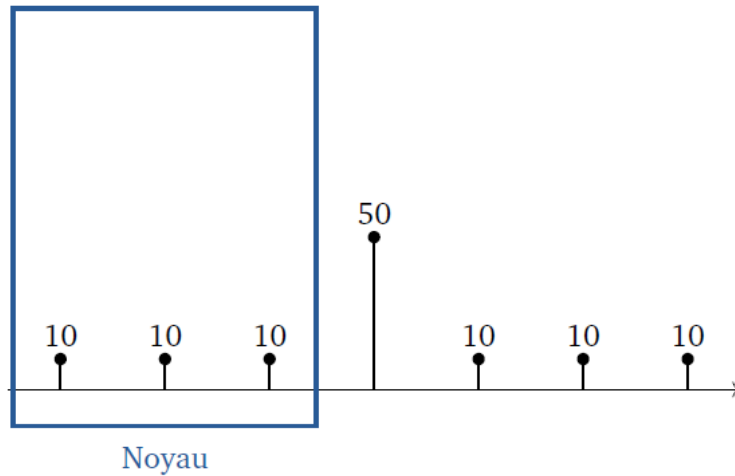


x	30	?				x
---	----	---	--	--	--	---



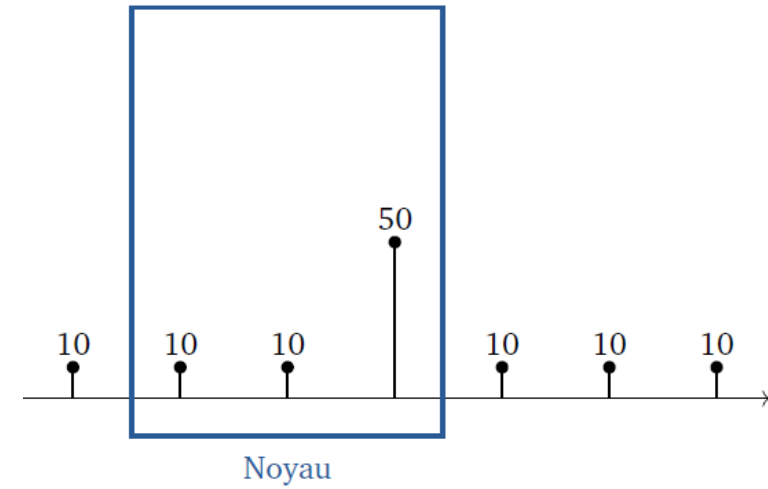
Convolution 1D

Principe



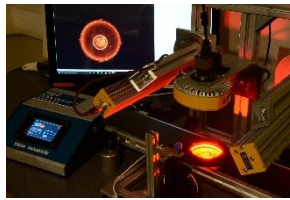
x	?					x
---	---	--	--	--	--	---

x	30					x
---	----	--	--	--	--	---



x	30	?				x
---	----	---	--	--	--	---

x	30	70				x
---	----	----	--	--	--	---



Convolution 1D

Exercices

$$A3 = \begin{bmatrix} 1 & 1 & 1 \end{bmatrix}$$

$$A5 = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 \end{bmatrix}$$

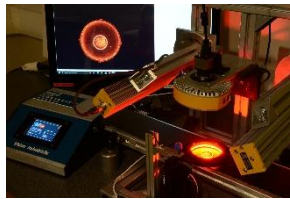
$$B = \begin{bmatrix} 1 & 4 & 1 \end{bmatrix}$$

$$C1 = \begin{bmatrix} -1 & 0 & 1 \end{bmatrix}$$

$$C2 = \begin{bmatrix} 1 & 0 & -1 \end{bmatrix}$$

$$S1 = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 100 & 100 & 100 & 100 & 100 \end{bmatrix}$$

$$A3 > \begin{bmatrix} & & & & & & & & & \end{bmatrix}$$



Convolution 1D

Exercices

$$A3 = \begin{bmatrix} 1 & 1 & 1 \end{bmatrix}$$

$$A5 = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 \end{bmatrix}$$

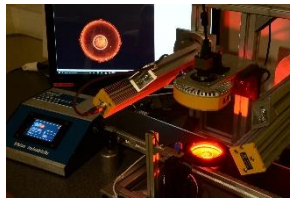
$$B = \begin{bmatrix} 1 & 4 & 1 \end{bmatrix}$$

$$C1 = \begin{bmatrix} -1 & 0 & 1 \end{bmatrix}$$

$$C2 = \begin{bmatrix} 1 & 0 & -1 \end{bmatrix}$$

$$S1 = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 100 & 100 & 100 & 100 & 100 \end{bmatrix}$$

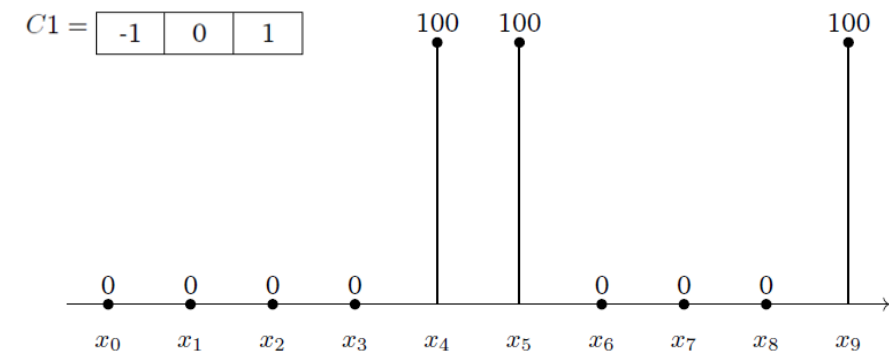
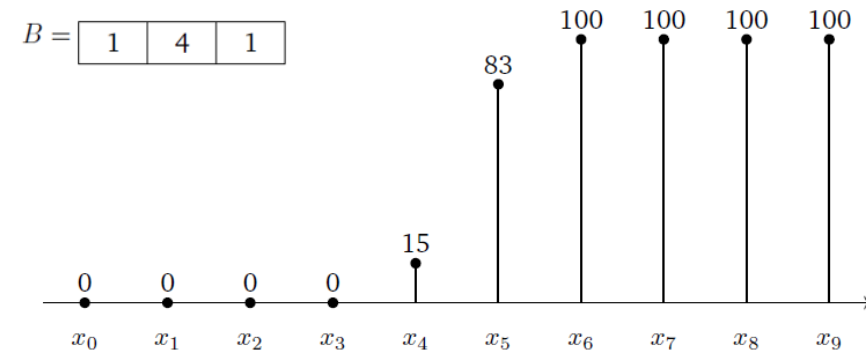
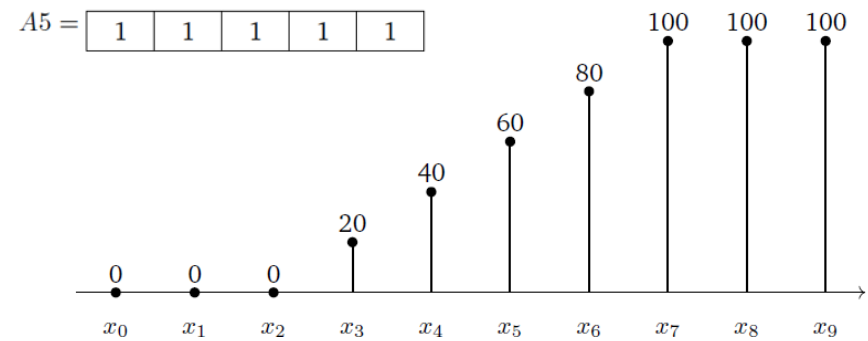
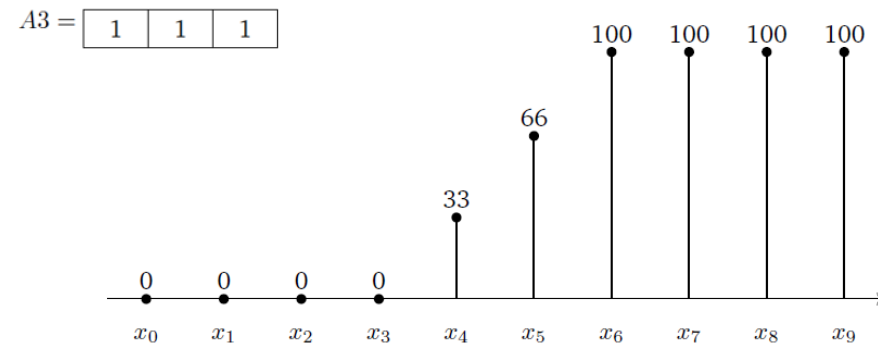
$$A3 > \begin{bmatrix} & & & & & & & & & \end{bmatrix}$$

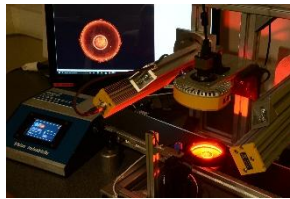


Convolution 1D

Résultats

$$S1 = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 100 & 100 & 100 & 100 & 100 \end{bmatrix}$$

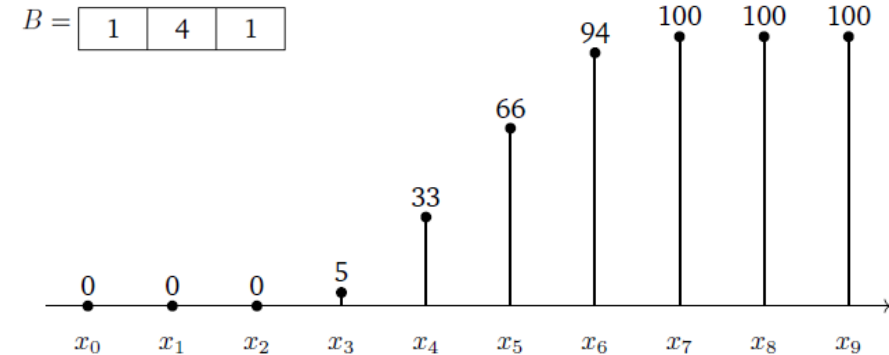
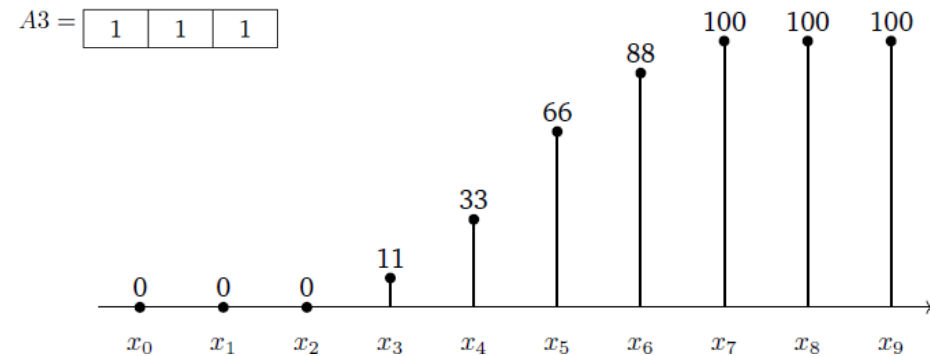




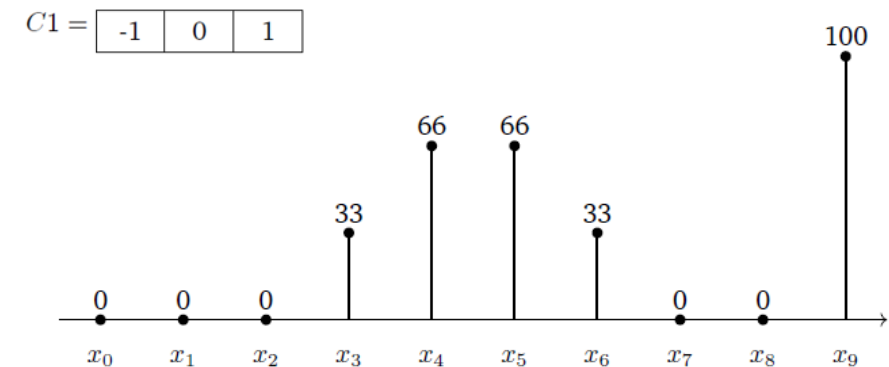
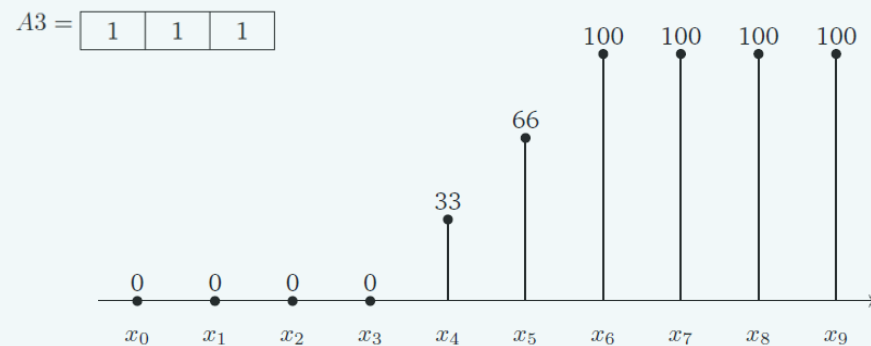
Convolution 1D

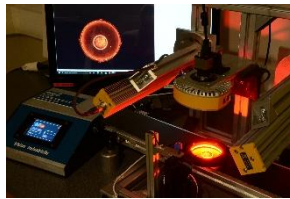
Résultats

$$S2 = \begin{bmatrix} 0 & 0 & 0 & 0 & 33 & 66 & 100 & 100 & 100 & 100 \end{bmatrix}$$



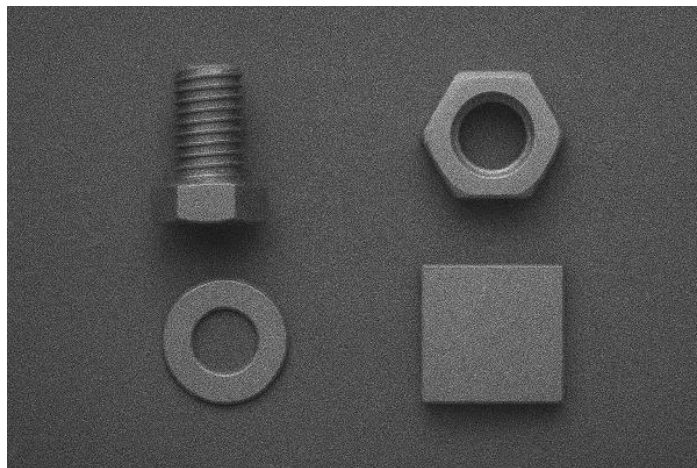
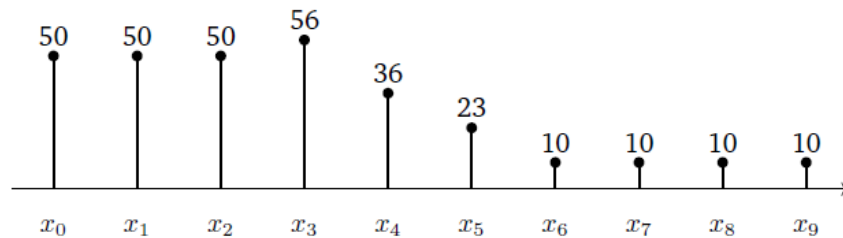
$$S1 = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 100 & 100 & 100 & 100 & 100 \end{bmatrix}$$





$$S3 = \begin{bmatrix} 50 & 40 & 60 & 50 & 60 & 0 & 10 & 20 & 0 & 10 \end{bmatrix}$$

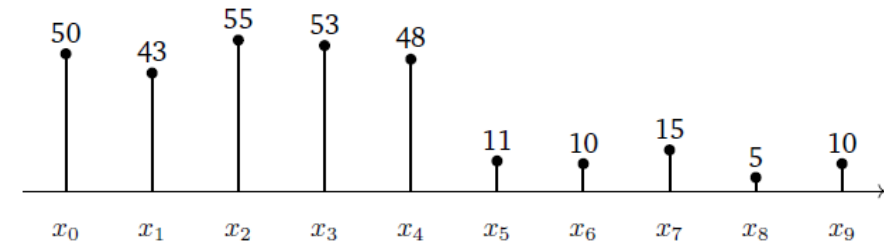
$$A3 = \begin{bmatrix} 1 & 1 & 1 \end{bmatrix}$$



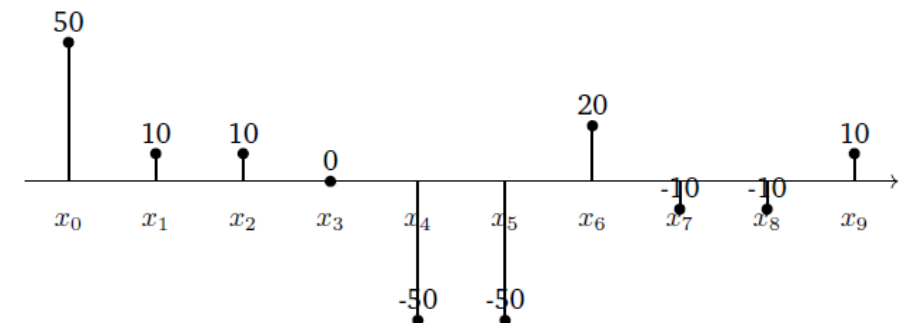
Convolution 1D

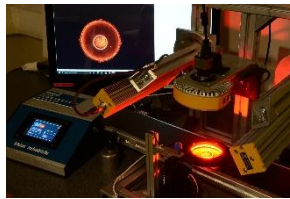
Résultats

$$B = \begin{bmatrix} 1 & 4 & 1 \end{bmatrix}$$



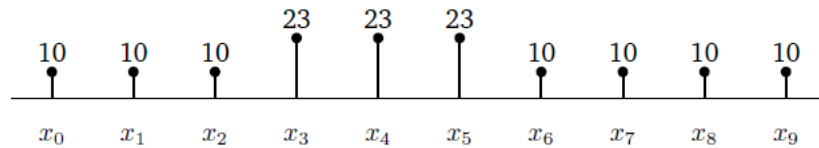
$$C1 = \begin{bmatrix} -1 & 0 & 1 \end{bmatrix}$$



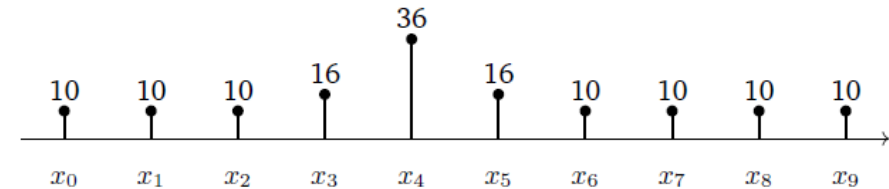


$$S4 = \begin{bmatrix} 10 & 10 & 10 & 10 & 50 & 10 & 10 & 10 & 10 & 10 \end{bmatrix}$$

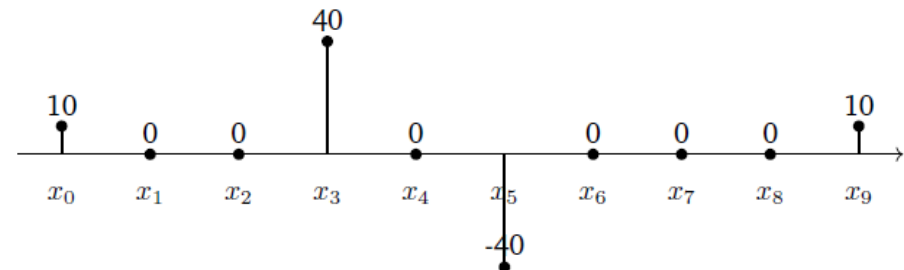
$$A3 = \begin{bmatrix} 1 & 1 & 1 \end{bmatrix}$$



$$B = \begin{bmatrix} 1 & 4 & 1 \end{bmatrix}$$



$$C1 = \begin{bmatrix} -1 & 0 & 1 \end{bmatrix}$$



Convolution 1D

Résultats